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MULTI-LAYER TOUCH-SENSITIVE DISPLAY DEVICE BASED  
ON ELECTROMAGNETIC ACTUATORS

Field of the invention

The invention is located in the field of devices intended to transmit touch-sensitive information to a user. It relates more particularly to a display device comprising:

- 5           - a touch plate with a touch-sensitive surface,
- a network of magnetic coils and a network of mobile parts for modifying the tactile sensation, the mobile parts being actuated as a function of currents flowing in the coils to produce on the touch-sensitive
- 10       surface a tactile sensation which is a function of the currents flowing in each of the coils.
- an addressing circuit to address current selectively to the different coils of the micro-actuators.

15           The magnetic coils actuate the mobile parts, which then deform a part of the touch-sensitive surface or make it vibrate. When the raised part of the touch-sensitive surface is deformed, or made to vibrate, a tactile sensation is produced that can be detected by

20       the user. The addressing circuit allows the selection of micro-actuators, which have to be actuated at a given time in order to produce at that moment the tactile sensation required.

25       Description of the prior art

US patent 6 159 013 describes a portable optical sensor for the blind. The device includes an

electromagnetic unit 1 shown in figures 1 and 2 of this patent. The electromagnetic unit shown in more detail in figure 3 of this patent comprises a touch plate 22. This plate comprises holes 21. Mobile rods 19, centred  
5 on each of the holes 21, can, depending on their axial position, cause a deformation of a touch-sensitive surface 32 on the touch plate 22. Each of the rods 19 is placed locally perpendicular to the touch-sensitive surface 32. A coil 7 placed to the rear of the touch  
10 plate 22 surrounds each of the rods 19. The coil 7 allows each of the rods 19 to be displaced in its axial direction. Depending on the value of a current flowing in the coil 7, one end of the rod 19 extends beyond or does not extend beyond the corresponding hole 21, thus  
15 modifying the shape of the touch-sensitive surface 32. In this way, a particular tactile sensation on the touch plate can be controlled at any time. In this embodiment example, an optical device 4, 5 placed upstream of the touch-sensitive device allows a written  
20 page to be converted successively, character by character, into digital data that is able to be reconverted into touch-sensitive data, in the way that a Braille reader is able to distinguish a string of characters in a touch-sensitive way.

25 It will be understood that the device employed in the aforementioned US patent may be useful in terms of delivering character based information, but that it quickly proves ineffective if the number of actuators has to increase. For a device that may reach several  
30 hundred actuators the method described in this patent can no longer be applied by reason of the complexity of

assembly and wiring, above all when the systems are to be miniaturised.

Brief description of the invention

5       The present invention proposes a touch-sensitive display device made by using the techniques of mass manufacture, particularly electrodischarge machining, laser scribing or microelectronics which can contain a great number of individual display components, each of  
10   which is able to be controlled individually, to form a display on a touch-sensitive surface.

      The invention therefore relates to a touch-sensitive display device comprising:

      - a touch plate with a touch-sensitive surface,  
15       - a network of magnetic coils actuating mobile parts to modify the tactile sensation, as a function of currents flowing in said coils so as to produce on the touch-sensitive surface a tactile sensation which is a function of the different currents flowing in each of  
20   said coils,

      - an addressing circuit to address currents selectively into the different coils,

      characterised in that:

      - the touch plate comprises a monolithic network  
25   of tactile sensation modification components, each network component comprising the set of mobile parts, each mobile part being able to be displaced under the action of a magnetic field, each set of mobile parts of a network component being subject to the field produced  
30   by one or more coils of the network,

- the magnetic coil network is in the form of a monolithic layer,

- an intermediate insulating layer is placed between the monolithic layer of coils and the touch plate, this intermediate insulating layer comprising,  
5 opposite each of the tactile sensation modification components, a recess procuring a mobility space for said set of mobile parts of this component.

In one embodiment, the set of mobile parts of  
10 tactile sensation modification components is constituted by one or more blade(s) integral with the touch plate via one or more arms, and resulting from a local cut in the plate that releases the blade or blades. The cut may be presented in the form of one or  
15 more grooves passing through the plate, present over the whole perimeter of the blade except for a blade connection part, these through grooves leaving one or more remaining arms connecting the blade to the whole of the touch plate. Thus, generally speaking, one or  
20 more blade release grooves are present in one part of a perimeter of the blade.

In an alternative embodiment the touch plate is sufficiently thick and the mobile parts are constituted by blocks constituting a magnet that can move by  
25 sliding in a hole in the touch plate.

In one embodiment, the coils are pancake coils, formed by flat winding a conductive track and placed on an insulating medium that is placed parallel to the touch plate and to the intermediate insulating plate  
30 comprising the blade displacement recesses. According to one variant of this embodiment one coil, one recess

and one tactile sensation modification component together constitute an individual display component. According to another variant of this embodiment a group of coils, one recess and one tactile sensation  
5 modification component together constitute an individual display component.

Preferably, in each of the embodiments the surface of a coil, or group of coils, corresponds substantially to the surface of the tactile sensation modification  
10 component actuated by this coil or group of coils.

In one embodiment, the addressing circuit is presented in the form of a printed circuit bearing tracks terminated with addressing contact pads, the contact pads coming into contact pads connection  
15 terminals of the coils. Electrical continuity between a coil connection terminal and the addressing contact pad of the addressing circuit corresponding to it can be ensured for example by pressing the contact pad against the terminal or by micro-welding a ball connection for  
20 example.

Thus in the embodiment which comprises at one and the same time the embodiment variant according to which the mobile blades are cut from the touch plate, the layer of pancake coils, and the addressing circuit in  
25 the form of a printed circuit, the display device according to the invention is presented in the form of a device made entirely by stacking layers parallel to each other according to the techniques of mass manufacture such as microelectronics. It then becomes  
30 possible to miniaturise to a high degree the tactile sensation modification components to produce a tactile

sensation that is a clear improvement relative to known devices.

The addressing circuit can be made according to the methods for manufacturing mono- or multi-layer  
5 printed circuits.

Other advantages and characteristics of the invention will emerge from the following description of embodiment examples.

10 Brief description of the drawings

Embodiments of the invention will now be described by means of the appended drawings, wherein:

- figure 1 shows an exploded perspective view of layers together constituting a display device according  
15 to the invention,

- figure 2 comprises parts A to H. Each of these parts shows an embodiment example of a tactile sensation modification component,

- figure 3 shows a diagrammatic view from above of  
20 a group of tactile sensation modification components forming a 7-segments display,

- figure 4 shows an enlarged perspective view of four layers together constituting the main structure of a device according to the invention,

25 - figure 5 shows in exploded perspective a layer of pancake coils and layers of a multi-layer printed circuit, these printed circuit layers together constituting a coil addressing circuit.

Figure 6 comprises parts A and B. Part A shows a  
30 plane view of a coil and blade constituting a tactile

sensation modification component; part B shows the same components in a transverse cross-section,

Figure 7 comprises parts A to I. Each of these parts is intended to explain modes of operation of tactile sensation modification components, as a function of the nature of these components and of the currents applied to control coils.

#### Detailed disclosure of particular embodiments

Figure 1 shows an exploded view of different layers together constituting a touch-sensitive display according to the invention.

The display device 10 shown in figure 1 comprises a touch plate 1 with a touch-sensitive surface 16. It also comprises a layer 3 comprising pancake coils 31. It also comprises a printed addressing circuit 4. In the example shown in figure 1, this circuit is constituted by conductive tracks 41-43, laid out on an insulating substrate 6. Between the touch plate 1 and the layer 3 of coils 31 is placed in accordance with the invention an insulating intermediate layer 2, this layer comprises recesses 21 of which more will be said below. In the example shown in figure 1, the touch-sensitive surface 16 is coated with an external protective layer 5 of blades constituting components for modifying the tactile sensation felt in contact with the touch plate 1.

In the example shown, the layer 3 of coils 31 comprises eight lines, each of eight coils 31. The coils are formed in matrix networks.

Likewise, the insulating intermediate layer 2 comprises eight lines each of eight recesses 21. There is a one-to-one correspondence between a coil and a recess 21. In the example shown, each of the coils 31 is presented in the form of a conductive spiral in the shape of a square. Likewise, the recess 21 are presented as holes with the peripheral walls thereof forming a cylinder of square cross-section. It is thus possible to define for each of the coils 31 and for each of the recesses 21 a central axis of the coil, and a central axis of the recess 21. In the case shown in figure 1, the central axes are the axes locally perpendicular to the centre of a coil, or to the centre of a recess.

It is said that the central axes of the recesses and of the coils are locally perpendicular to the layer of coils and to the layer of recesses, because naturally, the different layers 1-4 together constituting a display device according to the invention, might not be plane, but take any shape, in particular any shape that can be obtained by deforming a plane layer. In every case, the different layers are locally parallel to each other.

In the example shown, the central axes of a coil 31 and of a tactile sensation modification component 11, coincide. This arrangement is not mandatory, and mainly depends on the shape of tactile sensation modification components 11, and on the mode in which these components are actuated. It will be seen below that in some embodiments, it is preferable to offset the central axes of the coils 31 and components 11. The



important thing is that the recess 21 is able to allow the movement of mobile parts together constituting a tactile sensation modification component.

Embodiments of tactile sensation modification components 11 will now be commented on in connection with figure 2. This figure comprises eight embodiment examples of a tactile sensation modification component. These examples are identified in the figure from A to H.

10 In each of the examples shown, the tactile sensation modification component 11 is presented in the form of a rectangle 11. An inner peripheral part 15 of this rectangle comprises matter. This peripheral part is connected by one or more arms 13 to one or more  
15 blades 12. Groove 14 present in a central part of each rectangle 11, over a part of the perimeter of the arms 13 and of the blades 12 allow the blades 12 and the arms 13 to be released from the rest of the touch plate 1. The grooves 14 release the blade over its whole  
20 perimeter except at the places forming the junction zone between an arm 13 and the blade 12. Likewise, the grooves 14 release the arm or arms 13 over the whole of their perimeter(s) except for the places forming the junction zone between an arm 13 and the blade 12 at one  
25 of the ends of the arm 13 and between an arm 13 and the peripheral part 15 of the rectangle 11 at the other end of the two ends of the arm 13.

In the example shown in part A, a blade 12 is present in a central part of the rectangle 11. This  
30 blade is itself rectangular in shape, a first arm 13 connects a central part of one of the sides of the

rectangle forming the blade 12 to the peripheral full  
part 15 of the rectangle 11. A second arm 13 joins  
symmetrically the opposite side of the rectangle 12  
forming the blade 12 to the peripheral part 15 of the  
5 rectangle 11. In this way, the blade is connected to  
the rest of the touch plate 2 by two arms 13 aligned on  
one and the same axis.

The example shown in part B corresponds to a blade  
12 located, as in the case shown in part A, in the  
10 central part of the rectangle 11. This time, the blade  
12 is connected to the peripheral part 15 of the  
rectangle 11, by four arms 13 located  $90^\circ$  from each  
other. Each of the arms connects a central part of one  
side of the rectangle 12 constituting the blade 12 to  
15 the peripheral part 15 of the rectangle 11.

In the example shown in part C, the blade 12 is  
rectangular in shape. This blade is separated from the  
rest of the rectangle 15, by the presence of a groove  
14 having the shape of a cut groove 14 dug all around  
20 the blade 12, except for two parts forming junction  
zones of the arms 13 and of the blade 12. As shown in  
part C in figure 3, one part of the groove for  
releasing the blade 12 is contained inside the  
rectangle constituting the blade 12. In this way, the  
25 blade 12, is formed by two grooves symmetrical one with  
the other, each of the grooves being C-shaped. The arms  
13 are constituted in this case by two tongues 13  
symmetrical one with the other, and located between the  
two Cs.

30 In the example shown in part D in figure 2, the  
blade 12 is formed in a central part of the rectangle

11, by two channels 14 in the form of grooves each of which is U-shaped. Each of the Us is formed by a central part and two lateral parts perpendicular to the central part. The two lateral branches of a first U are  
5 located inside the second U. In this way, the arms are formed between the lateral parts of the first and second U.

In the example shown in part E, the central blade 12 is also formed by two U-shaped grooves 14. In this  
10 example a first U has one of its lateral parts located between the two lateral parts of the second U. The other of the lateral parts of the first U is located outside the two lateral parts of the second U. In this way, arms 13 are formed between the lateral parts of  
15 the first and second U.

In the example shown in part F, the blade 12 is formed by a C-shaped groove 14 entirely surrounding a central rectangular part forming the blade 12 except for the part 13 forming an arm joining the blade 12 to  
20 the peripheral part 15 of the rectangle 11.

In the example shown in part G, the blade 12 is in the shape of a spiral cut in the rectangle 11 by a groove 14 itself in the shape of a spiral.

In the example shown in part H, the blade 12 is  
25 circular in shape connected by arms 13 to the rest of the rectangle 11. This shape is obtained by removing material between two concentric circles forming grooves 14 in the form of parts of circular sectors. The arms 13 are formed by matter remaining between the grooves  
30 14 in the form of parts of circular sectors.

It may be noted that in each of the examples shown in figure 2, the tactile sensation modification components 11 are presented in the form of a single blade 12, one part of the perimeter of which is released from the continuum of the touch plate 1, by grooves 14, in number equal to the number of arms 13 connecting the blade 12 to the continuum of the touch plate 1. In this way in the cases shown in parts F and G there is one connection arm 13 and only one groove 14. In the cases shown in parts A, C, D, E, there are two connection arms 13 and two grooves 14. Finally in the cases shown in figure B and H, there are four and eight connection arms 13 and four and eight grooves 14 respectively.

The examples of blades shown in figure 2 are given as examples, and are by no means restrictive. Each tactile sensation modification component has been shown by a rectangle 11, but it should be understood that the different rectangles 11 together composing the touch plate 1 are adjacent to one another, in such a way that the touch plate is presented as a continuum comprising grooves 14 releasing the blades 12, these blades being attached to the continuum by the arms 13. The touch plate is therefore a monolithic structure constituting an assembly of blades.

Another mode of arranging the tactile sensation modification components 11 will now be commented on in connection with figure 3. In this embodiment, the tactile sensation modification components 11 are each presented in the form of a single blade, this blade being longilinear in shape in an axial direction, the

blade being connected to the plate by two arms for example on one of the large sides of the rectangle, the components 11 being grouped on the plate in groups of 7 together forming a 7 segments display. Figure 3 shows a view from above of one part of the touch plate 1 comprising a group of 7 tactile sensation modification components 11 together forming a 7 segment display. 7 segments displays of this kind are known per se for the display of alphanumerical signs. In this embodiment, the blades are longilinear in shape, for example rectangular. The blade remains integral with the continuum of the touch plate by means of two arms 13 connecting one of the long sides of the rectangle to the continuum of the plate. The arms 13 preferably connect the blade to the plate from the long side internal to the 7 segment display. A coil or a group of control coils 31 is provided for each of the blades, a set of seven coils or seven groups of coils each controlling one segment of a 7 segments display being addressable by a character generator also known per se. In the case of a group of coils for controlling a blade of a segment, the group is preferably composed of coils in the form of spirals appearing in a rectangular shape one of the sides of which has a dimension substantially equal to the width of the blade part located facing this coil. The coils of a group are preferably addressable simultaneously.

Figure 4 shows a local enlarged view of figure 1.

This figure shows a part of the stack of layers together constituting a touch-sensitive display according to the invention.

The printed circuit layer 4 constituting the addressing circuit is mounted on a substrate 6. The layer 4 is constituted by an insulating medium on which are laid out conductive tracks 41, each joining an edge of the printed circuit at a track contact end 45 with an end of a coil 31 constituting one of the coils of the layer 3. In figure 4 two tracks 41 can be seen. One of the contact ends 45 of the track 31 with an end of a coil 31 can be seen, and the other is masked by the layer 3 of coils.

The layer 3 of coils 31, which is immediately above the layer 4, is constituted by an insulating medium 33 comprising a conductive track 32 in a spiral, each of the tracks constituting a pancake coil 31. Coil construction of this type is known per se and will not be described here. One end 35 of a conductive track 32 forming a coil 31, for example the central end of this track, is in contact with a contact end 45 of a conductive track 41 of the addressing circuit 4. Each track 41 of the addressing circuit addresses one coil 31, and only one, of the coil layer 3. In the example shown in connection with figures 1 and 4, and as indicated above, the layer 3 of coils 31 comprises eight lines each of eight coils 31. The coils are formed in a matrix network. This arrangement is not mandatory. In particular in the case of tactile sensation modification components grouped to form 7 segment displays as shown in connection with figure 3, each coil or group of coils is preferably formed of one or more convolutions which appears (or appear) in a longilinear shape corresponding substantially to the

shape of the blade controlled by this coil or this group of coils.

The locations of coils or groups of coils 31 are arranged in such a way that the magnetic field of a coil or a group of coils is strong in the mobile parts of a tactile sensation modification component, when for example a coil or group of coils faces a mobile part, for example a blade, or weak in the mobile parts not controlled by this coil or this group of coils.

The electrically insulating layer 2 comes immediately above the layer 3 of pancake coils 31. This layer comprises a set of recesses 21. In the example shown in figure 4, the surfaces of the tactile sensation modification components, the surfaces of the through recesses 21, substantially the surfaces of the coils 31 of the layer 3 are substantially equal to each other.

Finally the touch plate 1 constituted for example by a magnetic metal film comes immediately above the insulating layer 2 comprising the recesses 21. In the example shown, the blade 12 constituting each of the tactile sensation modification components complies with the example shown in figure 3, part E.

One embodiment of a printed circuit for addressing the coils will now be described in connection with figure 5. Figure 5 shows an exploded view of a layer 3 of pancake coils 31 and of three layers 46-48 together forming a multi-layer printed addressing circuit 4. In this example, the layer of coils comprises eight columns of eight lines of coils 31. Addressing is carried out through the tracks 41-44 of the multi-layer

circuit which come into contact with the centre of the coils. Each one can therefore be addressed independently. This configuration is of great advantage when the number of coils is very high. In the situation  
5 where the layer of coils comprises eight columns, eight lines, one mono-layer circuit would be sufficient.

In the examples of addressing circuits shown in figure 1 or 5, there is a single addressing per coil. This assumes that an end of the convolution  
10 constituting the coil is connected to the earth, the second end constituting the addressing end.

The different modes of operation of display devices as shown in connection with figures 1 to 5 will now be commented upon in connection with figures 6 and  
15 7.

It is first of all specified that the blades 12 can be either made from a magnetic material, for example magnetic spring steel, or comprise layers which can be magnetised such as soft iron or a magnetic iron  
20 oxide or a rare earth, or again these blades can be fitted, for example by bonding, or attraction due to magnetic force, with a magnet.

When an alternating current is supplied to a pancake coil or a group of pancake coils 31, the  
25 blades, which constitute a tactile sensation modification component and which are in the field of this coil or this group of coils, are made to vibrate. The tactile sensation is thus modified as a function of the fact that the blades 12 vibrate or do not vibrate  
30 according to whether an alternating current passes through or does not pass through the pancake coil. The



selective addressing of the coils, which is known per se and not commented upon here, thus allows a particular configuration to be given to the touch plate 1 as a whole.

5           An arrangement wherein an axis of a coil 31 is not aligned with an axis of a tactile sensation component 11, will now be commented upon in connection with figure 6. This figure comprises parts A and B. Part A shows in a view from above a coil 31, shown in the  
10 diagram by a square and a part of a touch plate 1 at the level of a tactile sensation component that has a form in which the blade is cut out by means of a groove 14 constituted by a double U as described in connection with figure 3 part D, the two lateral parts of one of  
15 the Us being partially inside the two lateral parts of the other U. As shown in figure 6, the outer cut U of a blade is found entirely above the coil 31. Conversely the inner U is found partially outside the coil 31. In part B, the same components are shown in transverse  
20 cross-section. When a direct current is applied to the coil 31, one part of the U is for example attracted towards the coil 31. In this way, the other part is lifted as shown in figure 6, part B. A sensation of embossing is thus obtained above the touch-sensitive  
25 surface 16 embodied by arrows in figure 6.

The force exerted by the coil or the group of coils can, depending on the relative layout of the blades and coils, cause deformation by twisting or bending.

30           Other embodiments and details about the embodiment as well as additional information about the materials

potentially constituting a part of the tactile sensation modification components will now be commented upon in connection with figure 7.

Figure 7 comprises parts A to I. Each of these parts is intended to explain operational modes of tactile sensation modification components, as a function of the nature of these components and of the currents applied to control coils.

Each of the parts A to I shows diagrammatically the form or position of a mobile part 12 located in the magnetic field of a coil 31 as a function of a direct current which is applied to this coil.

In the case shown in parts A and B, the mobile part is a blade 12 in a magnetic material or comprises layers of magnetic material. When no current is applied to the coil 31, the blade 12 is in a first off position, for example flush with the touch plate 1, as shown in part A. When a direct current is applied, as shown in part B, the blade 12 is attracted towards the coil 31 and is found in a second operative working position, creating for example a cavity sensation on the touch plate 1, and an impact sensation, in the case of an alternating current, due to the return force of the arm.

In the cases shown in C, D and E, the mobile part is a magnetic blade 12 constituted by a material forming a magnet or comprises connected magnets. In this case if there is no current flowing in the coil 31, as shown in part C, the blade is found in a first off position. On the contrary if a forward direction current as shown in part D, or reverse direction

current as shown in part E, is applied to the coil 31 the blade is found in one of two operative working positions.

Parts F and G correspond to the case where the mobile part 12 is in the form of a blade 12 made in a very flexible material for example copper-beryllium or a spring steel, and where the magnet 17 is bonded under the blade. As regards the coil 31, it comprises a central channel 38 allowing the magnet 17 to be received. Part F is a perspective view of the blade 12 fitted with its magnet and part G is a transverse cross-section in which it can be seen that the magnet in an off-position, corresponding to the fact that the coil 31 is not being supplied, is partly inside the central channel 38 of the coil 31. Such an arrangement makes it possible to increase, the current being constant, the force generating the displacement of the blade constituting the tactile sensation modification component 11.

The case shown in parts H and I corresponds to the situation where the mobile part 12 is presented in the form of a block detached from the touch plate 1 and able to slide in a hole 14. Part H shows a view from above of a mobile part and of its coil and part I a transverse cross-section. Depending on the value of a current flowing in the coil 31, the part 12 emerges more or less from the touch plate 1, thus modifying the tactile sensation.

The layers constituting the device are not necessarily plane, but can on the contrary be adapted

to different curves, for example on a portable structure like a glove used in virtual reality.

CLAIMS

1. Touch-sensitive display device (10) comprising:

- a touch plate (1) with a touch-sensitive surface (16),

5 - a network of magnetic coils (31) actuating mobile parts to modify the tactile sensation, as a function of currents flowing in said coils (31) so as to produce on the touch-sensitive surface (16) a tactile sensation which is a function of the different currents flowing in each of said coils (31),

10 - an addressing circuit to address currents selectively into the different coils (31),

characterised in that:

- the touch plate (1) comprises a monolithic network of tactile sensation modification components (11), each network component (11) comprising the set of  
15 mobile parts (12), each mobile part being able to be displaced under the action of a magnetic field, each set of mobile parts (12) of a network component (11) being subject to the field produced by one or more  
20 coils (31) of the network,

- the magnetic coil network is in the form of a monolithic layer,

- an intermediate insulating layer (2) is placed between the monolithic layer (3) of coils (31) and the  
25 touch plate (1), this layer comprising, opposite each of the tactile sensation modification components (11), a recess (21) procuring a deformation space for said set of mobile blades (12) of this component (11).

2. Touch-sensitive display device (10) according to claim 1 characterised in that:

the set (11) of mobile parts (12) of tactile sensation modification components is constituted by a set of one or more blade(s) (12) integral with the touch plate (1) via one or more arms (13), one or more blade release grooves (14) being present around part of a blade (12) perimeter.

10 3. Touch-sensitive display device (10) according to claim 2 characterised in that,

the tactile sensation modification components (11) are presented in the form of a single blade (12), one part of the perimeter of which is released from the continuum of the touch plate (1), by grooves (14), in number equal to the number of arms (13) connecting the blade (12) to the continuum of the touch plate (1).

20 4. Touch-sensitive display device (10) according to claim 2 characterised in that,

the mobile parts (12) comprise a block constituting a magnet that can move by sliding in a hole (14) of the touch plate.

25 5. Touch-sensitive display device (10) according to claim 2 characterised in that,

the tactile sensation modification components (11) are each presented in the form of a single blade (12), this blade (12) being longilinear in shape in an axial direction, the blade (12) being separated from the continuum of the plate (1) by grooves (14) edging a

central part of the blade (12) on either side of edges of the blade (12) substantially parallel to the axial direction, the components (11) being grouped on the plate in groups of 7 together forming a 7 segments  
5 display.

6. Touch-sensitive display device (10) according to claim 5 characterised in that blades (12) of 7 segment displays are each integral with the continuum  
10 of the touch plate by means of two arms (13) connecting the blade (12) to the continuum of the touch plate (1).

7. Touch-sensitive display device (10) according to one of claims 5 or 6 characterised in that blades  
15 (12) of a segment face a group of coils (31) of the layer of coils (3), the coils of a group being in the form of spirals inscribed in a rectangular shape.

8. Touch-sensitive display device (10) according to one of claims 1 to 7 characterised in that mobile  
20 parts (12) are made of a magnetic material or comprise layers of magnetic material.

9. Touch-sensitive display device (10) according to one of claims 2 to 7 characterised in that blades  
25 comprise layers constituting a magnet or comprise a magnet fixed to the blade.

10. Touch-sensitive display device (10) according to one of claims 1 to 9 characterised in that mobile  
30 parts (12) comprise a magnet (17), in that coils (31)

comprise a central channel (38), the magnet (17) of a mobile part (12) being housed in an off-position corresponding to the fact that the coil (31) is not supplied with current, at least partly, in said central  
5 channel (38) of the coil (31).

11. Touch-sensitive display device (10) according to one of claims 1 to 6 or 8 to 10 characterised in that,

10 the coils (31) are pancake coils placed on a layer (3) placed parallel to the touch plate (1) and to the intermediate insulating layer (2), in such a way that one coil (31), one recess (21) and one tactile sensation modification component (11) together  
15 constitute an individual display component.

12. Touch-sensitive display device (10) according to one of claims 1 to 11 characterised in that,

the coils (31) are pancake coils placed on a layer  
20 (3) placed parallel to the touch plate (1) and to the intermediate insulating layer (2), in such a way that one group of simultaneously addressable coils (31), one recess (21) and one tactile sensation modification component (11) together constitute an individual  
25 display component.

13. Touch-sensitive display device (10) according to one of claims 1 to 12 characterised in that,

the addressing circuit (4) is presented in the  
30 form of a printed circuit (4) bearing tracks (41-44) terminated with addressing contact pads (45), the



contact pads (45) coming into contact with connection terminals (35) of the coils (31).

14. Touch-sensitive display device (10) according  
5 to claim 1

characterised in that it is constituted in the form of a stack of parallel layers (1-5), and comprising, in addition to the touch-sensitive surface (1) and the intermediate insulating layer (2), a layer  
10 of pancake coils (31) each constituted by a plane convolution of a conductive track (32), placed on an insulating medium (33) the planes of the coils (31) on the insulating medium (33) being parallel to the planes of the other layers (1-5), the addressing circuit (4)  
15 itself being in the form of a flat circuit comprising tracks (41-44) terminated with addressing contact pads (45), the contact pads coming into contact with connection terminals (35) of the coils (31), the different components carried by the layers being placed  
20 in such a way that a coil or a group of coils (31), a recess (21) allowing the displacement of the mobile parts (12), and a mobile part (12) is aligned in a direction substantially perpendicular to the plane of the layers.

ABSTRACTMULTI-LAYER TOUCH-SENSITIVE DISPLAY DEVICE BASED  
ON ELECTROMAGNETIC ACTUATORS

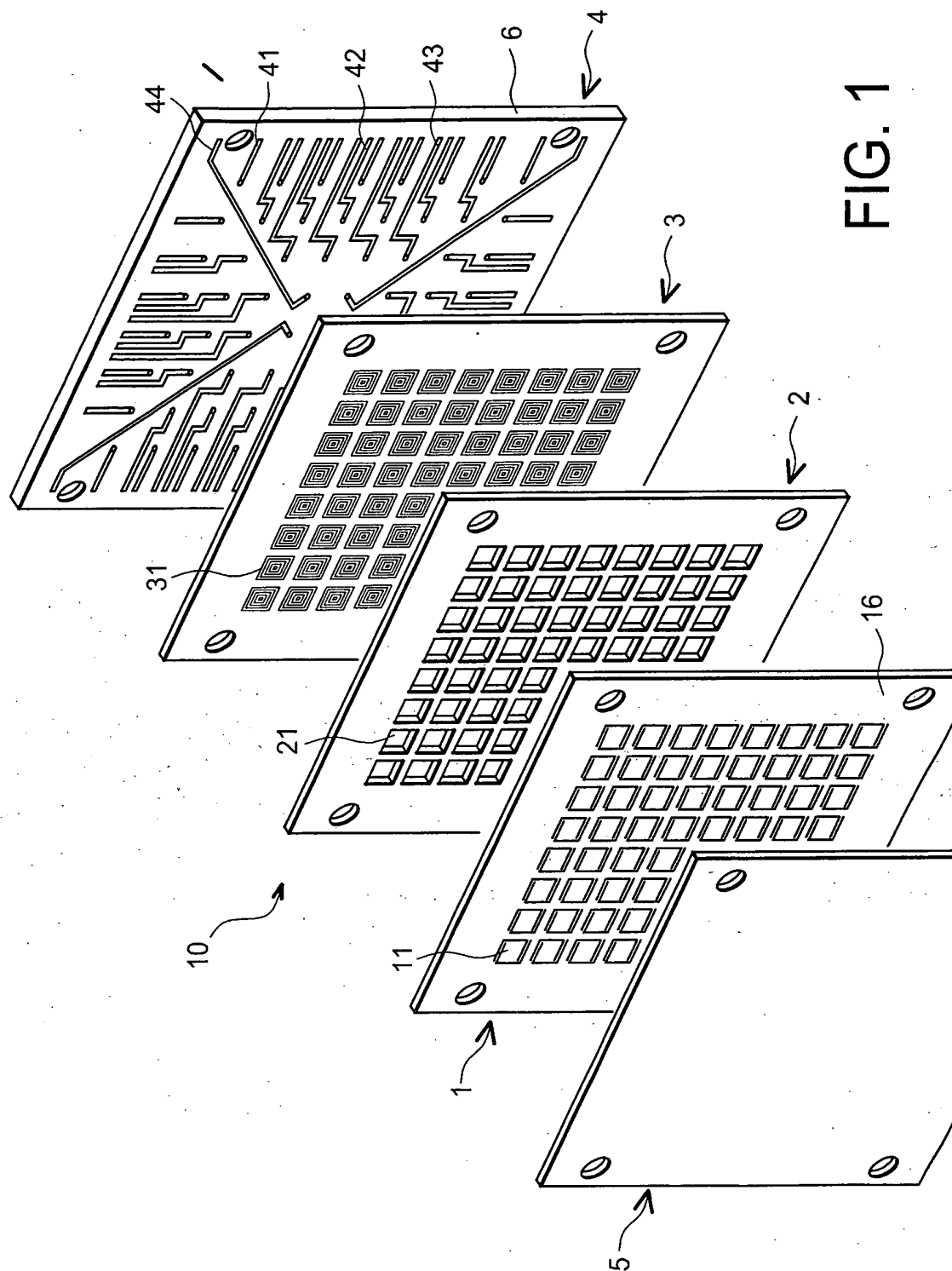
A touch-sensitive display device (10) is characterised in that it is constituted by a stack of layers (1, 4), an insulating layer (2) comprising recesses (21) for the displacement of blades (12) connected to a touch plate (1) being positioned between the touch plate (1) and a layer (3) comprising pancake coils (31) that can be addressed selectively.

By modifying the value of currents sent to the different coils (31), the feel of the touch plate (1) can be modified.

Figure 4.

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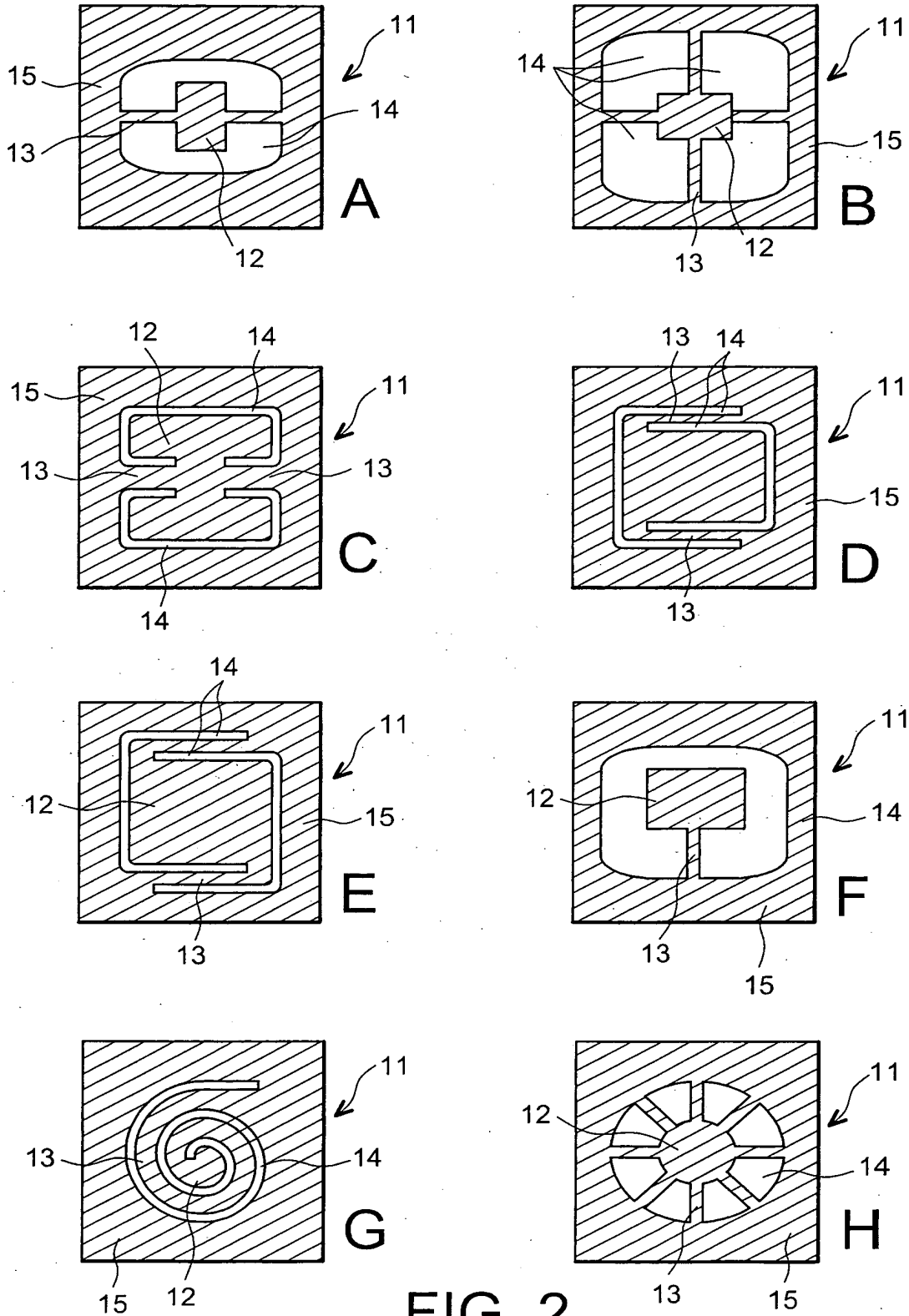


FIG. 2

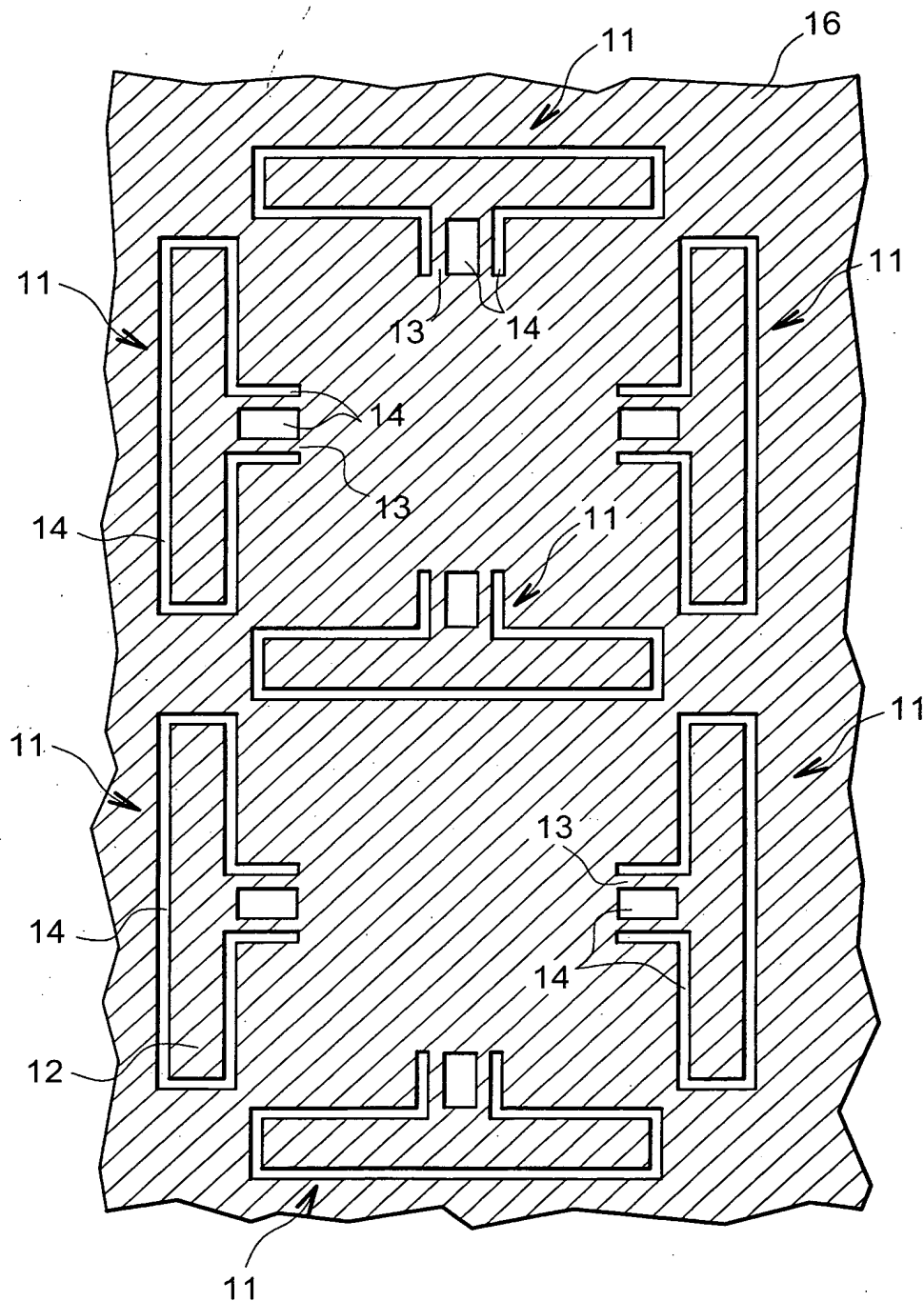


FIG. 3

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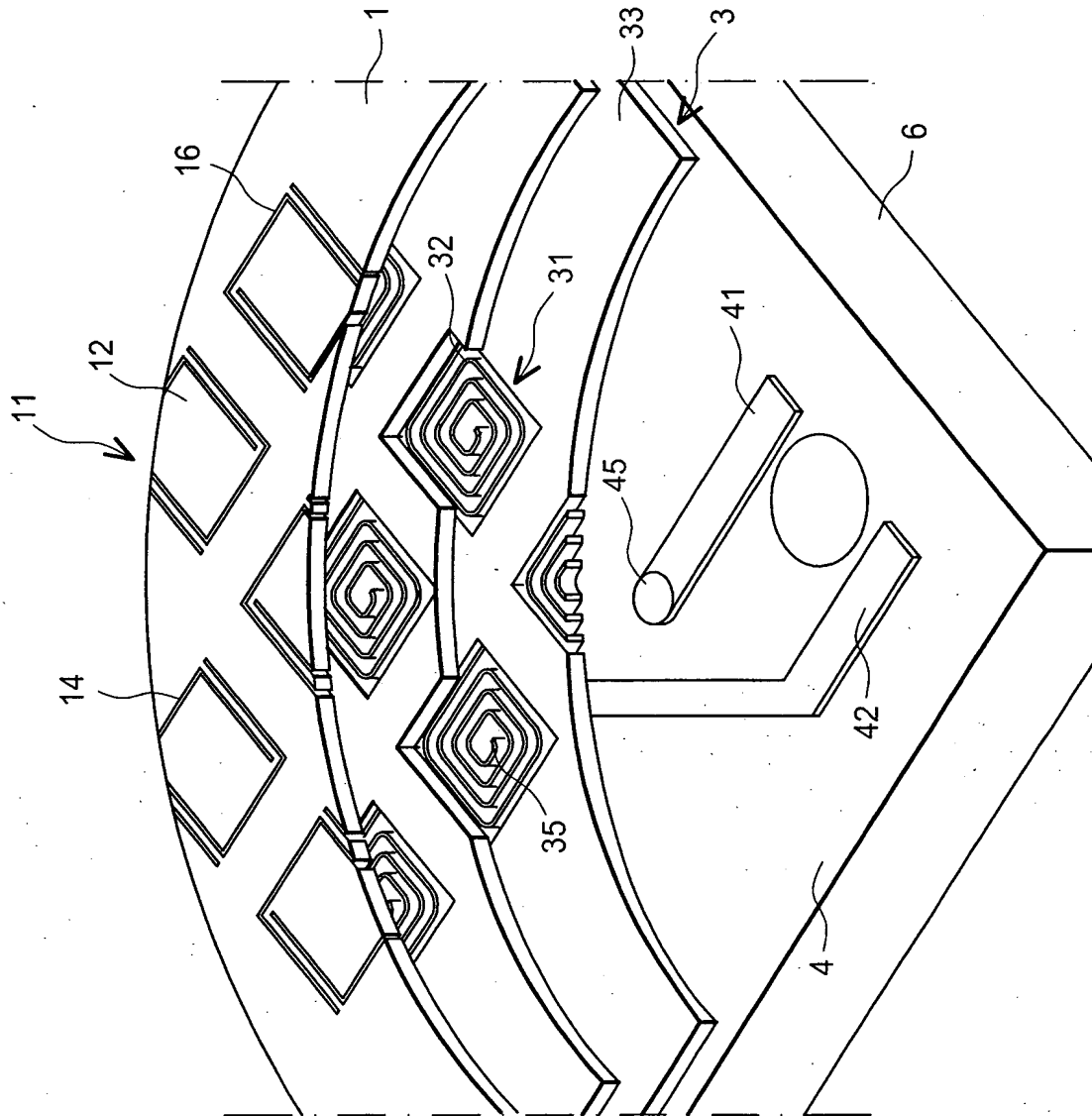


FIG. 4

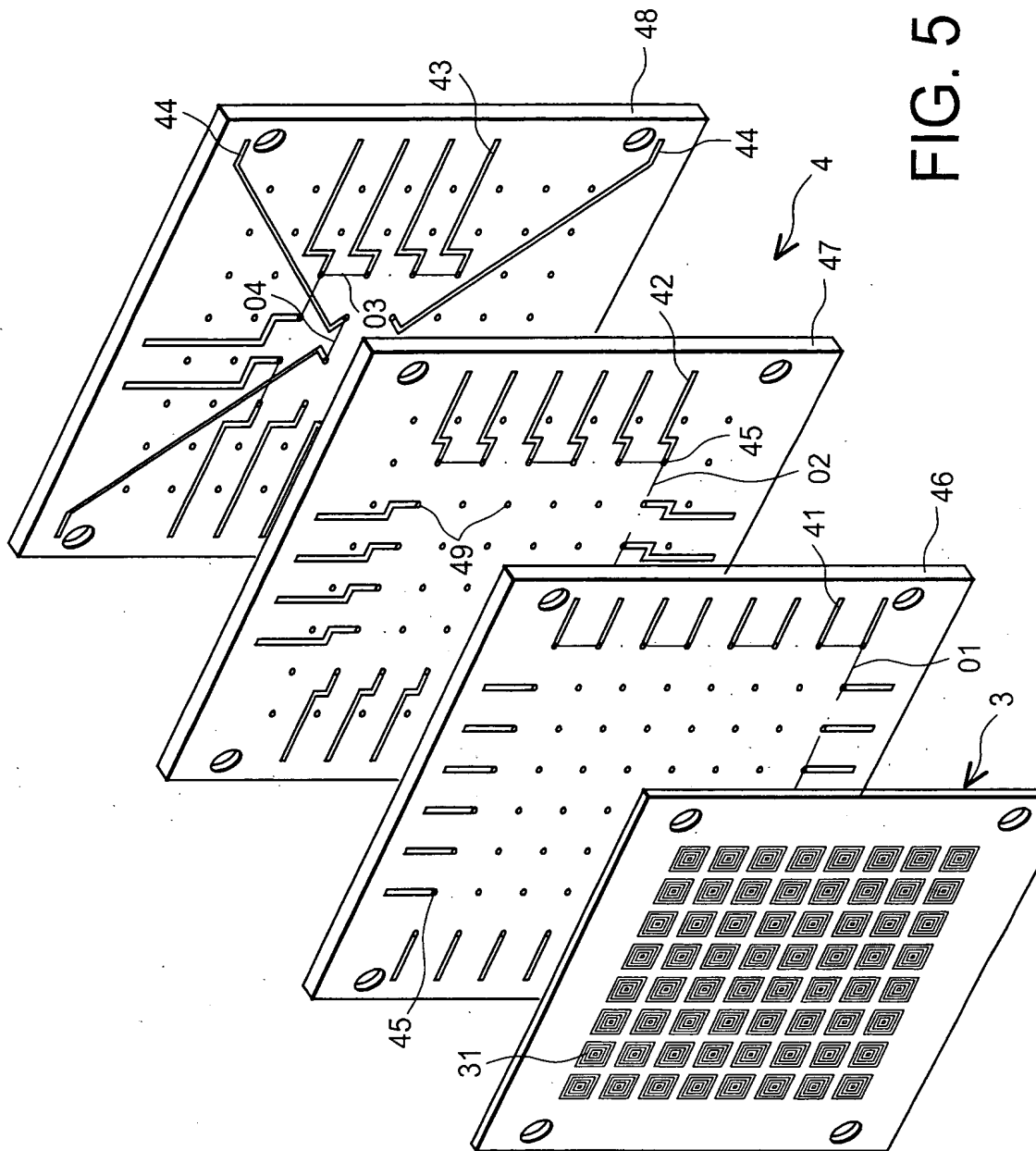


FIG. 5

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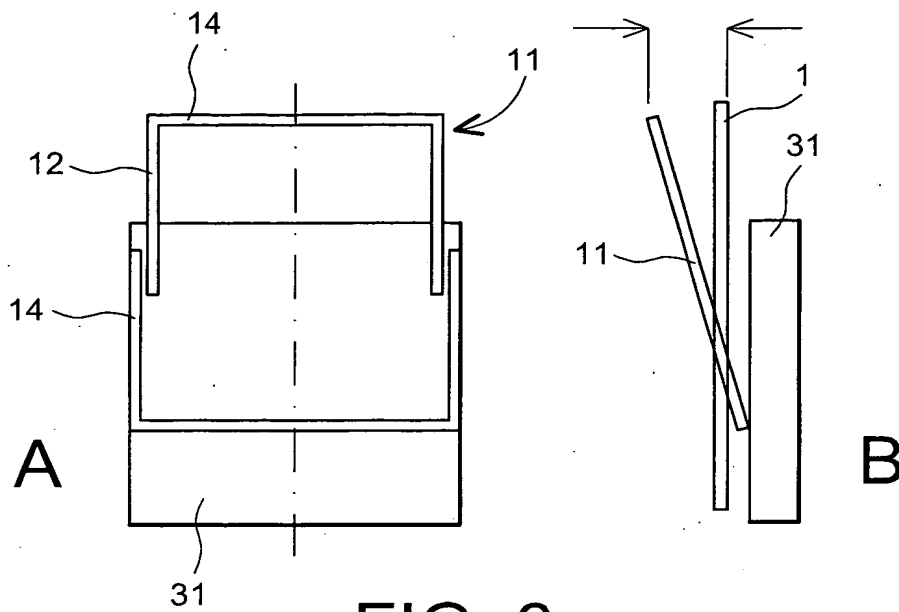


FIG. 6

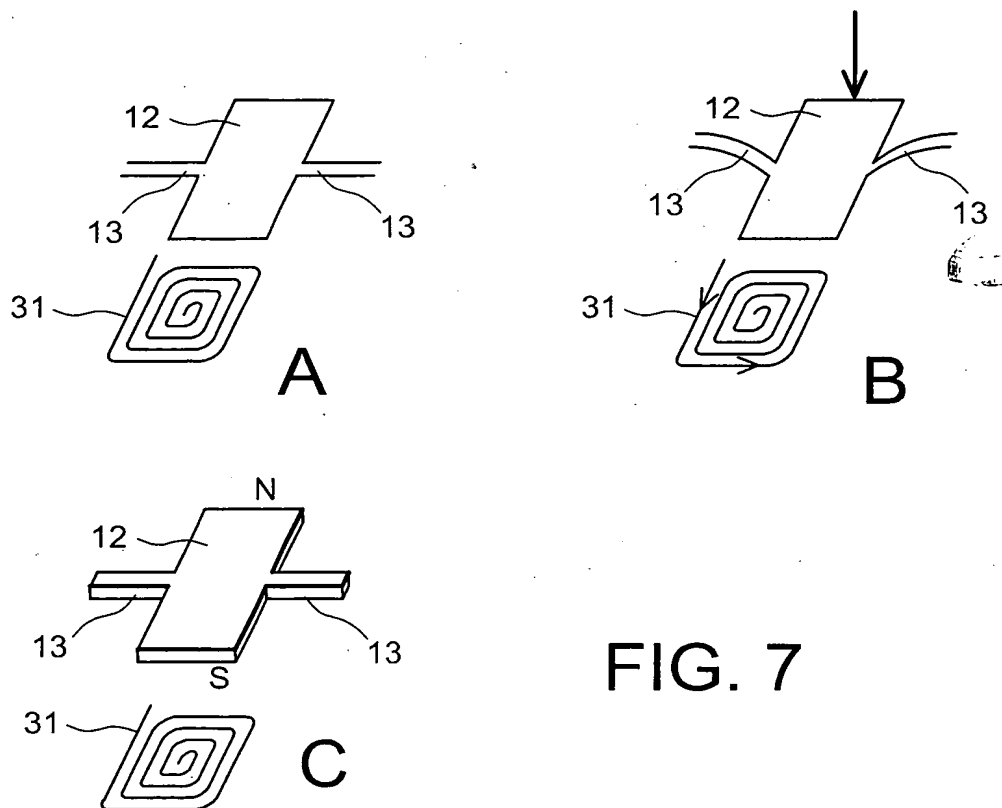


FIG. 7



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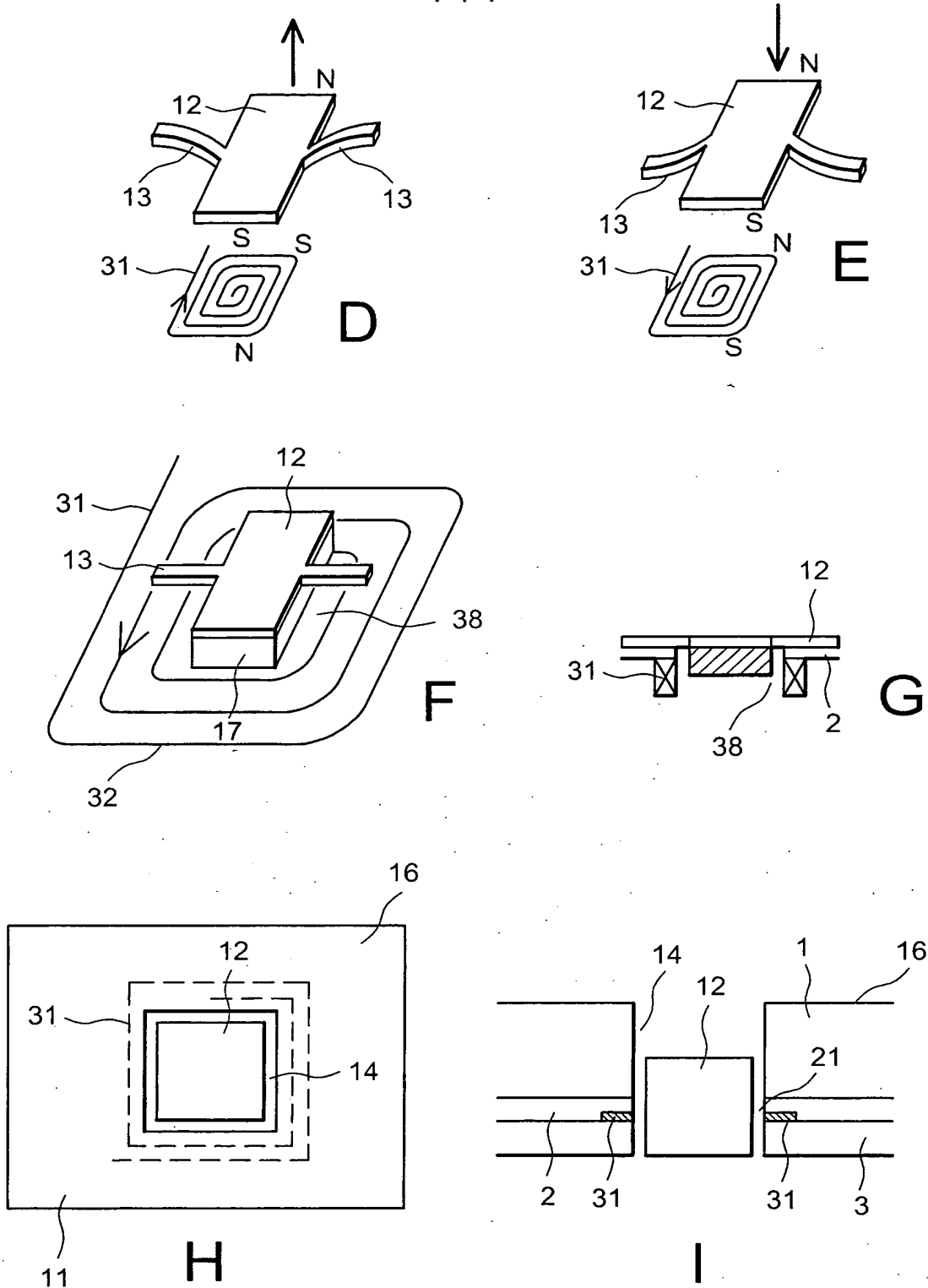


FIG. 7